FILTER*MAG* vs HOME BREW

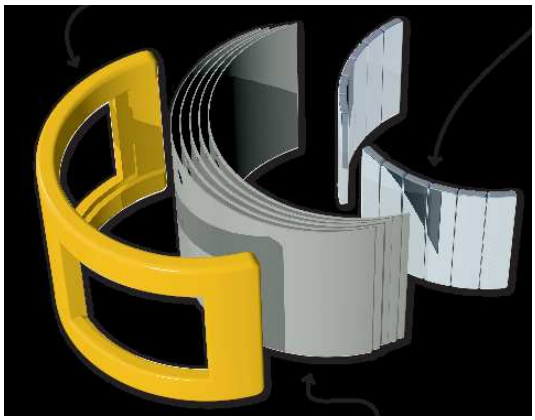
- By *WilsonNiblett-Ripoff.com* *

WilsonNiblett-Ripoff.com hates all kinds of auto scams be it dishonest, incompetent dealers or crappy, fraudulent products! But we're also interested in product alternatives, combinations of products and techniques that have a noticeable improvement even if the 'big three' ignore it.

We're halfway through our series of tests and reports on Oil, Oil Filters and various gadgets. Today we'll decide if FilterMAG™ makes a difference. We'll look at product claims, features, construction, packaging, instructions and performance via oil filter dissections and Oil Analysis. Any plan for highly extended oil drain intervals should include some Oil Analysis and regular oil level checks and top-ups.

WHAT THEY CLAIM:

1) FilterMAG makes various claims including reducing wear metals up to 87%[(1)] using an ISO 4406 tests that relies on particle counts rather then metals PPMs[(2)] . It's expected that PPM reductions using more affordable oil analysis measured in PPMs and by metals type will be more modest.



3 FilterMAG images from their website.

2) Deposits in the images above from the FilterMAG website may be extreme. A typical oil filter from a car used in street legal applications will see less build up depending on mileage. However, every bit of ferrous metal pulled from the oil is good. In our tests we could see a pattern of wear metals inside the filter housing shell where the FilterMAG is, that's good, since you're catching what the oil filter is missing. This is all you want to see if you expect your car to last more then a few years! This also means the overall wear is 'normal'. Very hard driving, towing, racing, etc, will produce more wear particles and more accumulation. If you can discern individual particles, that's serious wear issue.

** See page 11 for Terms* *(_) Footnotes are on Pg 11.*

3) Various test examples quoted by FilterMAG[3] are hydraulic oil applications with run times nearly twice what occurs in on-road automotive use and at engine loadings far higher then on-road use.

4) The FilterMAG website claims magnets used are specially made for high temperature oil applications. However, it does not specify the maximum temperature limit. Our tests of homebrew magnetic oil filtering using the least expensive neodymium magnets with a max working temperature of 175 F *may* became 20% weaker in 8 months with 200 F engine oil, we'll have to see.

5) FilterMAG telephone support [4] indicated max working temperature for FilterMAG magnets is 300F and a low limit of - 40 F. Below - 40 F damage will occur, above 300 F the FilterMAG begins to weaken slowly. (At the 'curie temperature' - over 650 F, the magnets become instantly non-magnetic.)

6) The best way to measure magnet degradation is with a DC Gaussmeter, but at a cost of over $800 for a typical meter, we'll use a weight scale. Considering the cost of this product it would be good to know that they will last for years and not weaken just outside the 1 year warranty period.

7) FilterMAG claims there's a shield built in to 'focus the magnetic field', hard to tell if that's true. But the shield does stop metals from sticking to the outside of the FilterMAG, only the inside, that's good.

8) Overall, we consider FilterMAG to be a worthwhile product, just a bit pricy with typical US prices around $48 each, according to size. We bought 2 so we can track aging and see if it's an issue.

WHAT YOU GET:

9) FilterMAGs can be bought directly from their website, shippable to US addresses only. Alternate sources are Jegs.com, Ebay.com, SummitRacing.com, etc. There appears to be no retail store sales and no sales channel thru racing shops. Just as well, retail markup would be prohibitive.

10) FilterMAGs come as shown in the pics, the filtermag is in a foam pouch. Be sure not to drop it since magnets can crack and the plastic overmold housing could also crack and separate.

FILTERMAG INSTALLATION:

11) Correct positioning helps get the most out of a FilterMAG as per these pics. Place the FilterMAG near the middle of the filter not the very top or bottom. If you want to see what's collected, leave it on as you remove the filter, drain it and cut it open. Ditto if you use separate magnets in para 16.

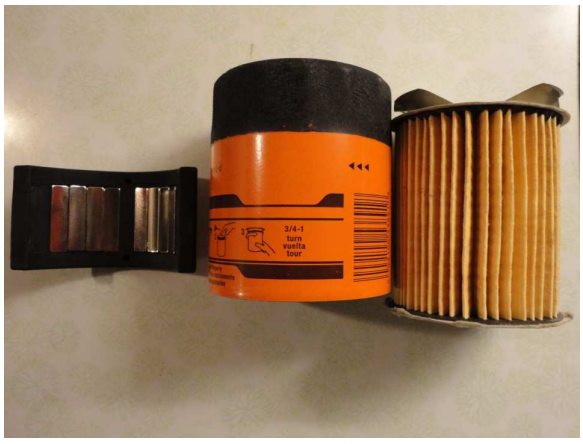
Prevents use of filter cutter

Best

Prevents use of filter wrench [15]

12) FilterMAG states you can '*snap on and slide off*' the FilterMAG during oil changes, this works well. They warn NEVER pry off the FilterMAG with a screwdriver, this will cause the plastics to crack and separate from the magnets and the shield. We agree.

13) The Pic [5] below shows the relative position of the FilterMAG to the filter media and the filter shell [6]. The top of the filter has a space for the filter spring used to hold the filter cartridge against the spin-on base. A magnet on the filter dome-end is *nearly ineffective* by comparison and should be avoided on it's own unless you use other magnets as noted in this paper first. Update: no change in PPM data found was found in subsequent oil tests (2016).



14) The strength of the FilterMAG thru the filter housing was surprising as seem in the pic above, typical auto oil filter housings are thin deep draw low alloy steel. These screws and nuts required several pounds of force to remove! This is key: the total pull strength between the magnet and metal particles is heavily affected by the particle's extremely small size and the relative thickness of the oil and oil speed. Particles have to come fairly close before they are pulled out of the oil flow. To capture any one specific particle requires many passes before it's close enough to stick, this is normal.

HOME BREW:

15) Our 'homebrew' test setup to get reduced wear metals in the engine oil of a late model GM car consisted of:

- 1 good quality magnetic oil drain plug.
- 1 neodymium magnet carefully positioned inside the filter center tube [7]
- 2 neodymium magnets on the outside of the oil filter.

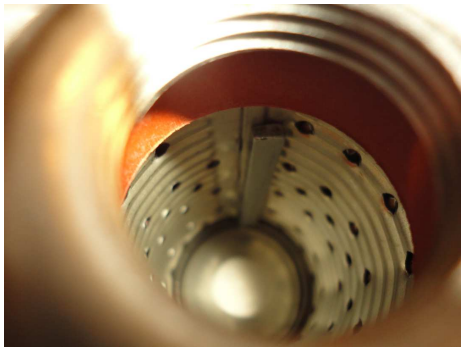
16) The neodymium magnets used are 2" long x 3/32" thk x 3/16" wide and are of the most common working temperature Spec of 175 F, anything higher is special order. The size above allows them to be used on most filters of any diameter with a good fit, where much wider magnets will rock or wobble and arc magnets of exactly the correct radius dimension are hard to get.

17) Typically, this style and shape of neodymium magnet is magnetized thru it's sides or thickness rather then through the ends. The red ink signifies the 'North' pole in the Pic below. This is useful in our current application giving maximum magnetic pole exposure thru the filter shell.

18) The neodymium magnet down the center tube of the oil filter carries a risk that if improperly positioned, it may move or be sucked into the engine. We positioned the magnet on the tube seam in this FRAM filter where there are no oil holes. So far, so good after 10,500 miles / 17,000Kms. Getting the magnet into the filter was trickier then we thought, don't try it unless you can accept the consequences of a malfunction and engine damage if an oil passage is blocked [7]. Once inside, the magnet is difficult to move or reposition and near impossible to remove. Some filter brands (WIX™, etc) have seamless center tubes that won't provide a place to solidly seat the magnet in place.

19) The 2" long neodymium magnet was used inside the FRAM test filter is unlikely to be forced by oil pressure into the engine since it's too long to make a complete turn to go down the center of the engine's oil filter fitting which has a much smaller inside diameter then the filter spin-on diameter shown. That's the fail-safe that's being relied on here. Short magnets may be easier to dislodge.

20) There's a range of magnetic oil plugs from cheap to premium with a big difference in the strength and surface area. Clearly, greater strength and more surface area exposed to the oil provides more opportunity for particles to stick. Surprisingly, in 2 years of driving, magnetic oil plugs was the least affective device used.



Long bar magnet inside filter

Typical red mark is the North pole

Various magnetic oil plugs

In the left Pic above, the magnet is positioned on a flat spot near the inner tube seam and was subsequently slid up under the lip of the backflow valve to reduce any chance it could be dislodged and pushed into the engine.

21) Here's the installed pic for the 'homebrew' setup with two 2" long neodymium magnets on the side. 4 to 6 bar magnets can be used instead of a FilterMAG. The bar magnets shown cost $2.00 each as surplus items.

22) After oil samples are collected at the correct mileage, the bar magnets were removed and replaced with 1 FilterMAG as shown below. The car was run for another 2,000 Kms / 1,250 miles roughly equal to 49 engine hours, also see a note in para 34. FilterMAG claims improvement in applications in just 20 hours, we find this overly optimistic, measurable improvement in 50 -100 hours.

23) When the 2" bar magnets where removed it was noticed they may be 20% weaker after 8 months, 13,200 Kms or 320 engine hours [8] with an average oil temperature of 200 F. [9]

2 individual bar magnets, 1 visible
There's room for lots more!

1 FilterMAG installed
(room for 2 if at least ¾" clearance to block)

FILTERMAG RESULTS AT 4,000Kms / 2,500 miles:

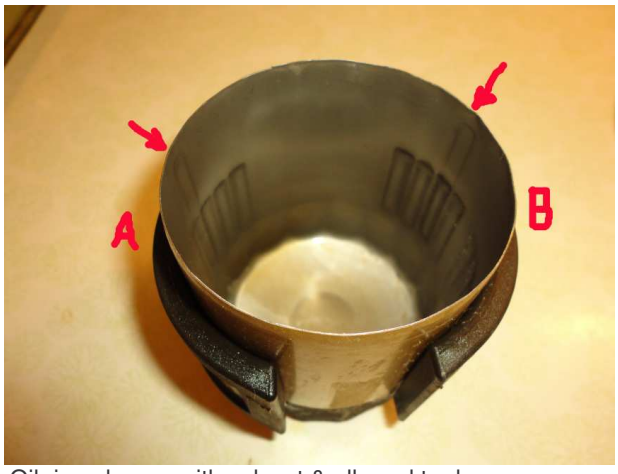
24) To see how well any filter magnets work it's key they are located on the filter so the filter can be taken off with a filter cap socket and leave enough leave room to cut off the filter shell without moving the magnets out of position or the collected wear metals will be released back into the oil as it is empted out. Go back to para 11 and the Pics on that page.

25) We installed one FilterMAG and accumulated 4,000 KMs. We checked clearance around the filter on the engine to see if there was room for a second FilterMAG (ie 360 degree clearance) and ordered a second one and installed it with 2,000 Kms accumulated. Surprisingly, several high performance cars use small oil filters crammed into small place on the engine allowing almost no room to mount a FilterMAG which is almost ½ " thick. This is where the 'homebrew' selection of magnets mentioned in para 16 would work well.

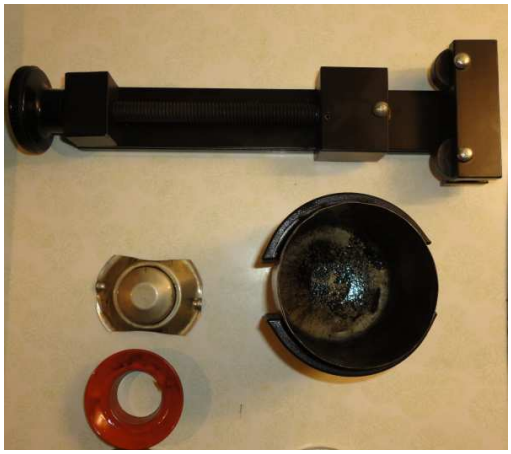
26) We removed the filter and kept the FilterMAGs in place throughout and never moved them so we can recover the captured wear metals inside the filter. The steps we took include:
- use a small screwdriver to open the rubber back flow valve [10] to empty the filter of oil.
- use the oil filter cutter to cut the filter open.
- carefully extract the filter media cartridge without touching the shell walls. [11]
- invert shell to allow oil drain into paper towel.
- take photographs to show pattern of accumulated metals inside filter shell along with residual oil.
- use Varsol to rinse out oil with a swirling motion and leave metals only, drain inverted, let dry.
- take photographs again.
- remove FilterMAGS, then capture wear metals on a tissue wipe in one pass and save the wipe.

27) The Pics below are surprising: this test car shows wear levels on the oil analysis reports that are far below the average at just 12 to 15 PPMs, yet there is very visible accumulations at 2,000Kms and 4,000Kms! Hard driving, towing, street racing will cause wear metals from 50 to 150 PPMs or more, 10 X more then seen here! Vintage cars easily fall into the 50 PPMs range.

Filter shell removed, oil present



Oil rinsed away with solvent & allowed to dry
A – 2,000 Kms **B** – 4,000 Kms
Arrows show shadows left by bar magnets



Filter cutter shown

Overview after wiping

Wipe patch, metals caught

28) The total distance on the oil filter was just over 17,000 KMs, means there's 3 times more wear metals that could be caught! If we prorate that over the full distance of a car up to the time it is scrapped out or sold, the amount would be surprising! All of it free to circulate with any typical oil filter premium or economy!

29) Arrows show the shadows left by the 2 bar magnets used for the first 13,238 Kms of the test, showing that they worked well to get a 20% reduction per the oil analysis reports. The Pics on Pge 5 show there's room for many more bar magnets on the outside of the filter, so go for it!

30) In a well equipped lab, the clean tissue wipe would be weighed in an enclosed Mettler™ lab scale capable of .0001 gram resolution and then weighed after the wipe up of metals to measure the metals collected. The metals weight can be used to predict the total wear metals over a longer period of time provided the driving style remains about the same. Wiping up the metals is done after the varsol dries to avoid weight errors.

31) With the correct type of microscope it would be possible to measure/scale the metal particle sizes and identify the most common particle sizes in the sample.

32) Remember, cars in the '60s, '70s' and '80s where still cheap in inflation-adjusted terms and the percentage of income used to buy and operate them. Nowadays, even cheap cars are expensive in the total ownership cost, it's nice to find ways to prevent early replacement. All vehicles are known in accounting circles as 'depreciating capital assets'. Why waste any more money on what is doomed to be a rust bucket when there are better ways to spent or invest your money?

OIL ANALYSIS REPORTS:

33) The oil analysis reports consist of 4 columns of data from 4 different oil samples drawn at 4 different times: (A to D labels are keyed to report image on next page)

'A' - **Control sample: (sampled June 4 /14)**
This control run was all factory OEM equipment, no add-ons, Quaker State™ 5W30 full synthetic, FRAM™ Synthetic filter, run for 13,236 Kms, 8,220 miles, 323 engine hours. Regular oil top-ups when found ½ litre / ½ quart low. That is, the oil was never stressed by running the oil so low that it could affect the results. Oil sample was drawn at oil change after a 1 hour cool down. (12)

'B' - **Homebrew setup: (sampled Dec 19 /14)**
This run has the homebrew setup described in para 15, new, same brand 5W30 full synthetic oil, FRAM Synthetic filter, run for 13,238 Kms, 8,221 miles, 323 engine hours. Regular oil top ups when found ½ litre / ½ quart low. Oil sampled after a 1 hour cool down.

'C' - **1st FilterMAG added on Dec 19 /14: (sampled Feb 4 /15)**
FilterMAG claims improvements in as little as 20 hours. We chose a test of 48 hours or 2,000Kms / 1,240 miles on the same oil in 'B' with all other magnets still in place with 1 FilterMAG replacing 2 outside magnets. This gives us a total of 15,238 Kms, 9,469 miles, 372 engine hours on the same oil. Regular oil top ups when found ½ litre / ½ quart low. Oil sampled after a 1 hour cool down.

'D' - **2nd FilterMAG added on Feb 4 /14: (sampled March 13 /15, - 176,742 Kms)**
In this part of the test we added the 2nd FilterMAG on the other side of the oil filter. The first FilterMAG will have 4,000 KMs on it and the second will have 2,000 Kms on it. The oil is the same as in 'C' above. The oil and filter now have 17,238 Kms / 10,700 miles, 420 engine hours. Regular oil top ups when found ½ litre / ½ quart low. Oil sampled after a 1 hour cool down.

'D' - **Oil / Filter Changed – 2 FilterMAGs: (done on March 13 /15, - 176,742 Kms)**
Complete oil / FRAM filter change with 17,238 Kms / 10,700 miles on the old oil and oil filter. The old filter was cut open as shown earlier. This new run will be for the original control distance of 13,238 Kms with 2 FilterMAGs, one bar magnet inside the filter and the same magnetic oil plug. The goal is get the wear metals as low as possible in the oil in an all-out effort. Next results will be column **'E'**.

MISTAKES MADE:

34) While there is good record keeping from the beginning, there was one mistake: When switching from 'homebrew' individual bar magnets to the FilterMAGs, metals where released back into the oil when the 'homebrew' bar magnets were removed to make room for the FilterMAG which resulted in an uptick in the PPMs report that was initially confusing and disappointing. Ooops!

35) What see from the reports is that engine oil (synthetic, in our case) can last far longer then we thought when we began this series of tests. Key for these tests is: late model car, no engine issues, no leaks, no excessive blow-by, good compression, no emission problems and no engine OBD II codes. The oil analysis report's data table is shown below:

		D	C	B	A
DATE SAMPLED		13-Mar-15	04-Feb-15	19-Dec-14	04-Jun-14
DATE RECEIVED		17-Mar-15	09-Feb-15	07-Jan-15	25-Sep-14
DATE REPORTED		19-Mar-15	10-Feb-15	08-Jan-15	29-Sep-14
LAB NO.		45010279491	45010274857	45010270936	45010252196
SIF NO.		14972252	14972251	14972248	14972249
TIME ON UNIT	Kms	176742	174742	172742	159504
TIME ON OIL	Kms	17238	15238	13238	13236
OIL BRAND		Quaker State	Quaker State	Quaker State	Quaker State
OIL TYPE		Unidentified	Unidentified	Unidentified	Unidentified
OIL GRADE		SAE 5W30	SAE 5W30	SAE 5W30	SAE 5W30
OIL ADDED					
FILTER		Changed	Not Changed	Not Changed	
OIL CHANGED		Changed	Not Changed	Not Changed	
WO NUMBER					
Metals (ppm)					
Iron (Fe)		14	14	12	15
Chromium (Cr)		<1	<1	<1	<1
Lead (Pb)		2	<1	<1	2
Copper (Cu)		7	9	7	9
Tin (Sn)		1	<1	<1	<1
Aluminium (Al)		7	7	5	5
Nickel (Ni)		<1	<1	<1	<1
Silver (Ag)		<1	<1	<1	<1
Titanium (Ti)		<1	<1	<1	<1
Vanadium (V)		<1	<1	<1	<1
Contaminants (ppm)					
Silicon (Si)		8	10	8	11
Sodium (Na)		12	15	13	48
Potassium (K)		<5	<5	<5	<5
Additives (ppm)					
Magnesium (Mg)		11	13	12	14
Calcium (Ca)		2507	3028	2703	2617
Barium (Ba)		<1	<1	<1	<1
Phosphorus (P)		758	870	795	797
Zinc (Zn)		888	1067	900	897
Molybdenum (Mo)		83	70	62	61
Boron (B)		<5	<5	<5	5
Contaminants					
Water (%)		<0.05	<0.05	<0.05	<0.05
Coolant		No	No	No	No
Physical Tests					
Viscosity (cSt 100C)		10.3	10.3	10.6	10.3
Physical / Chemical					
Base Number (mgKOH/g)		3.3	3.9	4.1	4.5

REPORT DISCUSSION POINTS:

36) There are some interesting observations to be made:

- **Oil Additive Levels:**

Considering that the same brand of synthetic oil was used from 2 different production lots in a car over nearly 2 years of real world driving, the additive levels are surprisingly close! This is one of the areas where more frequent top-ups at the ½ Litre mark rather then waiting to be down a full Litre helps. Most late model cars now have a total engine oil capacity less then the traditional 4.5 L. This 2009 Chev Impala test car is spec'd at only 3.8L oil capacity. So if you wait to be a full Litre low, you'll be running your engine with only 2.8L of oil for several thousand Kms and months at a time. The dipstick markings seem to agree with .5 L increments.

- **Oil Contaminants:**

These numbers are trending lower which is surprising since they're not magnetic. It's possible for materials to cling to ferrous particles and be drawn from the oil. Water contamination is holding steady well below the limit.

- **Metals: Iron (Fe):**

From the Control to the Homebrew we see a 20% drop and a small climb with the FilterMAG per the mistake made in para 34. Our original expectation was that wear metals would flat-line easily. It looks like getting *all* wear metals out of the oil requires far more effort. However, oil appearance is much better, looking only a few months old rather then 17,000 Kms plus and more then 8 months of use!

- **Metals: Lead (Pb):**

From the Control to the Homebrew we see a near 100% drop to 'trace' levels (<1ppm). Since lead levels in this carefully driven test car where well below limits that was not hard to achieve. Lead is not magnetic, but in the wear process the lead is soft and easily binds with the ferrous particles and is then pulled to the magnets together. This was a surprise, we'll have to see if the vintage test car does the same from much higher numbers. It's also logical that with less wear metals to cause secondary wear, the lead levels would drop as well. Because of the error in para 34, lead climbed back up in the last samples.

- **Oil Base Number:**

Base Number is an oil life rating figure, new oil is as high as 12, normal in-service oil is 8 to a low of 3 with 2 or less requiring an oil change. Considering different lots and times the same brand of oil was used, BN values at the same mileage are quite close and still serviceable. With a total of 17,238 Kms, on the same oil, the Base Number is still an acceptable 3.3.

HOW OLD IS THE OIL – REALLY?

37) In this run of 17,238 Kms, (10,700 miles) you'd think the oil is shot and the engine is damaged. The reality is that 80% of the oil is fairly new due to regular top-ups whenever the level on the dipstick dropped one notch, about 1/2 *L* / ~1 US pint.

38) A review of service notes for oil checks and top-ups, shows that out of a 3.8 *L* oil capacity for a 2009 GM V6, is that 3.3 *L* is top-up oil! Sounds bad but it turns out oil consumption is only **.**190 *L* (190 mL) every 1,000 Kms (600 miles). Typically, hiway speeds leads to slightly higher consumption.

39) Excessive oil consumption for any model car is decided by these 4 factors:

- Manufacturer's specification limits
- Any visible oil burning / fouling on the spark plugs

- Any visible blue smoke from exhaust pipe
- Any oil residue, excessive soot in the exhaust pipe

40) Once we crunch the numbers we can see that the risk to the engine from the oil and filter in this long test run with timely top-ups was very low as shown in the oil analysis reports.

CONCLUSIONS:

41) From this series of tests we can draw several conclusions:

> OEM or consumer brand name oil filters *seldom* filter out <u>any</u> normal wear metals that are well under ~20 microns in size (20 microns = .0005" / "half a thou").

> It's clear that *in most cases* a magnetic oil plug alone is not enough to make a difference. Multiple filtering points works best based on oil analysis reports.

> The 'homebrew' setup gave a 20% reduction in Ferrous metals with just 2 outside bar magnets and also carried away some lead to the magnets as previously described.

> It's a safe bet that using 4 or more 2" long [13] neodymium magnets spaced around the outside of the oil filter is sure to improve the wear metals reduction past 20% at far less cost then a FilterMAG.

> Magnetic filtering should be located at the conventional oil filter since all the oil must pass through it thousands of times when driven. Magnetic filtering in the oil pan via the oil plug is the least affective with no visible deposits found with the naked eye even after 17,000 Kms in the vehicles tested.

> Once magnets are in place, <u>don't move</u> or <u>remove</u> them, all collected metals will be swept back into the oil – you'll be back to square-one.

> It's important to remember primary wear can't be stopped completely and will occur based on driving style and engine load, removing the wear metals as they occur prevents secondary wear where these particles otherwise becomes a circulating abrasive. Most likely to affect compression, power, emissions and gas mileage further down the road as the engine 'ages'.

> Once it's known how the *Base Number* of your preferred oil brand degrades, it may be worthwhile to change the oil filter once during a test and cut it open and continue a test with a new filter fitted with FilterMAGs or the homebrew solution and test different filters using the same oil. In this series of tests, Base Number results show the oil could be run to 21,000 Kms before a Base Number of 2.0 is reached *requiring* an oil change.

> As a well treated and maintained engine's mileage climbs past 300,000 Kms /180,000 miles, blow-by and/or oil contaminants in the oil analysis may require a return to shorter oil change intervals [14] but with magnetic filtering in place, you'll always be better off !

NEXT STEPS: (in our test series)

42) With a complete oil change, new synthetic oil, new filter, 2 FilterMAGs etc, we'll do an oil test at 5,000Kms / 3,000 miles to see just how good engine oil is when we usually change it as frequently as the dealers and the quick lube industry 'recommends'. Also we'll have some good to great wear metal numbers for the 2 FilterMAGs without the error in para 34!

43) After the 5,000 Kms oil sample is taken, we'll add a magnetic end cap filter to see if that helps get us the 'flat line' wear metals numbers we want in our test fleet.

44) At the 13,238 Kms oil run interval, we'll drop the current FRAM filter, cut it open and photo document what we find at the 2 FilterMAGs. We'll run the same oil knowing the Total Base Number at 13,238 Kms was 4.1 to 4.5 and swap in WIX's™ best filter, the 'XP' with 2 FilterMAGs mounted and see what happens - our guess is WIX XP will have no real affect on the Oil analysis reports.

* LEGAL NOTE:

NOTE: The purpose of magnetic filtering is to extend engine service life by removing abrasive wear metals from the oil. Any plan for highly extended oil drain intervals should include some Oil Analysis and regular oil level checks and top-ups.

(1) Screen shots of FilterMAGs 87% claim was recorded.

(2) Oil Analysis reports listing PPMs of various metals found in engine oil more informative and less expensive then ISO 4406 particle counts.

(3) FilterMAG website examples /claims seen in January 2015.

(4) FilterMAG telephone support call recorded on April 13 2015. The max working temperature is not clearly stated on the FilterMAG website. Staff did not know what the actual 'Curie Temperature' spec, but where helpful.

(5) Due to closeup photography with a wide angle lens, some fisheye distortion present.

(6) Some new filters were harmed in the making of this report. Pic of cut filter shell appears shorter then actual since oil filter cutter removes lower .5" of filter.

(7) The risks of inserting magnets down the filter center tube was explained. Don't do it if you're a newbie.

(8) Engine times calculated from GM DIC display in the instrument cluster.

(9) Temperatures measured at oil filter with IR thermometer.

(10) Not all filters have backflow valves, where equipped, they are in the form of a rubber / nitrile / silicone, etc circular flap that covers the oil entrance holes. Push aside with a small screwdriver to allow oil to drain out before cutting open.

(11) When the filter media cartridge assembly inside the oil filter has steel end caps, there will be considerable pull from the FilterMAGs. If the cartridge drags on the inside wall of the filter shell, the wear metals deposits may be smeared.

(12) Most labs recommend taking an oil sample within 30 minutes. For the sake of uniformity, the original 1 hour interval is repeated for all new oil samples.

(13) Some vehicle applications have surprisingly small oil filters, in that case 1 ½" or even 1" bar magnets will fit better without interfering with the filter cap wrench or the Oil filter Cutter if you chose to use one.

(14) Vintage engines before the 1990's typically can't tolerate 20,000 Kms oil change intervals and may require shorter oil change intervals closer to the classic 5,000 Kms / 3,000 mile interval due to high blow-by and engines designed for leaded gas and older oil formulations, etc.

(15) Oil flow thru filter media greatest near spin-on end of filter. Best FilterMag results at mid position or closer to spin-on end, also applies if you use multiple individual bar magnets.

Rev 0c - Apr 22 2015 (updated 2017) written by: www.wilsonniblett-ripoff.com

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